ACTIVITY REPORT

July 2001

Natural Gas & Oil Technology Partnership

bringing department of energy national laboratories capabilities to the petroleum industry

Los Alamos
Los Alamos, NM 87545
(505) 667-7811

Sandia
Albuquerque, NM 87185
(505) 844-7333

Lawrence Livermore
Livermore, CA 94551
(925) 422-5196

Lawrence Berkeley
Berkeley, CA 94720
(510) 486-5085

Argonne
Argonne, IL 60439
(202) 488-2415

Brookhaven
Upton, NY 11973
(516) 344-3819

Idaho
Idaho Falls, ID 83415
(208) 526-7004

Oak Ridge
Oak Ridge, TN 37831
(865) 574-4977

Pacific Northwest
Richland, WA 99352
(509) 372-4565

To: William F. Lawson, Director
National Petroleum Technology Office
U.S. Department of Energy
P.O. Box 3628
Tulsa, OK 74101

From: J. Albright, Los Alamos
D.J. Borns, Sandia
F. Followill, Lawrence Livermore
G.M. Hoversten, Lawrence Berkeley
D. Schmalzer, Argonne
A. Goland, Brookhaven
C. Thomas, Idaho
T. Schmidt, Oak Ridge
B. Saffell, Pacific Northwest

cy: G. Dehoratiis, DOE Fossil Energy
E. Allison, DOE Fossil Energy
A. Hartstein, DOE Fossil Energy
B. Hochheiser, DOE Fossil Energy
G. Stosur, DOE Fossil Energy
E. Subia-Melchert, DOE Fossil Energy
S.L. Waisley, DOE Fossil Energy
W. Polansky, DOE Office of Science
N.B. Woodward, DOE Office of Science
D. Alleman, DOE-NPTO-Tulsa
J. Casteel, DOE-NPTO-Tulsa
N. Comstock, DOE-NPTO-Tulsa
B. Lemmon, DOE-NPTO-Tulsa
R. Lindsey, DOE-NPTO-Tulsa
D. Sutterfield, DOE-NPTO-Tulsa
J. Ammer, NETL
F. Brown, NETL
H. Guthrie, NETL
B. Gwilliam, NETL
R. Long, NETL
B. Tomer, NETL
A. Yost, NETL

Note: Natural Gas and Oil Technology Partnership projects are reported according to the following schedule:

January, March, May, July, September, November	**February, April, June, August, October, December**
Oil and Gas Recovery Technology Drilling, Completion, and Stimulation Technology Diagnostic and Imaging Technology	Upstream Environmental Technology Downstream Environmental Technology Ultra-Clean Fuels Technology

Natural Gas and Oil Technology Partnership on the World Wide Web: http://www.sandia.gov/ngotp/

Oil and Gas Recovery Technology

Improved Waterflooding Through Control of Brine Composition and Other Factors

(BP Amoco, U of Wyoming, and INEEL)

Highlights:

- Core from five wells selected for laboratory testing.

It was shown that by injecting diluted reservoir brine in laboratory cores, waterflood oil recovery can be significantly increased under certain circumstances compared to waterfloods using reservoir brine.

INEEL concluded a set of experiments that extends the positive results envelope to the Minnelusa formation of the Powder River basin, a major oil producing basin in northeast Wyoming and southern Montana. Results indicate that by using diluted reservoir brine as the driving fluid in waterfloods, oil recovery can be significantly increased. At the INEEL, two corefloods using full strength reservoir brine were very consistent and the recovery averaged 49.0% of the original oil in place. Five corefloods were done using a 100-fold dilution of the reservoir brine. Oil recovery ranged from 51.0% to 66.7% of the original oil-in-place, giving an average of 55.7%. This is an increase in recovery of 13.6%. All cores were Berea sandstone and saturated at room temperature (21° C) with Minnelusa reservoir brine and Gibbs crude oil (from the Minnelusa formation), but aged and flooded at 75° C.

At the University of Wyoming, researchers studied the effect that permeability differences have on this method of increasing oil recovery. They have consistently seen higher oil recovery using diluted reservoir brine using Berea sandstone of permeabilities ranging from 50 md to 1000 md.

These two findings are significant because it lays the groundwork on which to build other studies. Moreover, for the first time, we have demonstrated the same and comparable results using two different core containment methods. The waterfloods at the INEEL were done using epoxy coated cores, while the University of Wyoming used pressurized rubber-sleeve core holders.

Preparations are under way to scale-up the size of cores being tested to determine if core length has any impact on oil recovery increases due to dilute water injection.

Fluid Identification Acoustic Logging Tool

(BP Amoco, CGG, Chevron, Conoco, Landmark Graphics, Mobil, Schlumberger, Shell, Smedvig, Texaco, Unocal, Ward Petroleum, Western Atlas, and LANL)

Highlights:

- Carried out theoretical study to determine the effect of dissolved gas in liquids and its quantification.
- Investigated various circuitry for real-time tracking of sound speed and sound attenuation in a flowing fluid.

At high pressures, gas gets dissolved in liquid and is not always available as a free gas. Project researchers theoretically explored how sound attenuation and speed is affected by dissolved gas in a liquid. The effect on sound speed is small, but the frequency dependence of sound speed can be greatly affected by dissolved gas.

The project design for real-time monitoring of oil/water/gas composition continues. Various designs have been explored to find the optimum design, since each design has advantages and certain drawbacks. At least two good candidates were identified and project researchers plan to refine the design further.

High-Resolution Reservoir Characterization Using Seismic, Well, and Dynamic Data

(BP Amoco, Chevron, Exxon, Oxy, Phillips, RC2, Texaco, Western Geophysical, Texas A&M, and LBNL)

Report not received.

Measuring Sucker Rod Pump Parameters Downhole (Harbison-Fischer, Yates Petroleum, UT-Austin, Texas Tech University, and SNL)

Highlights:

- Plunger position measured using an array of Hall effect sensors.

Prototype downhole electronics, including the array of Hall effect sensors, were tested at the University of Texas sucker-rod pumping test facility. The electronics functioned properly, demonstrating the architecture chosen was robust.

A planning meeting was held at Harbison Fischer to determine how to reach closure on this project.Topics included how compressor chamber pressure could be measured using commercial off-the-shelf equipment and how to continue work on the project at the University of Texas.

Formation Logging Tools for Microboreholes (DeepLook, Texaco, and LANL)

Highlights:

- Fabrication of microhole deviation tool completed.
- Paper submitted and accepted for presentation at the International Energy Agency Conference.

Design and fabrication of a 1-in.-diameter tool for surveying microhole deviation was completed. Deviation will be surveyed using 3-axis magnetometers and accelerometers produced by Applied Physics, Inc. The tool will operate through a 3/8-in., 4-conductor wireline. Field testing will commence on completion of the microhole at San Ysidro, NM.

On the request of the DOE, a paper titled, “The Application of Microhole to the Development of Coalbed Methane Resources at Remote Locations,” was prepared and submitted for presentation at the upcoming International Energy Agency Conference in Vienna, Austria. Written in collaboration with personnel of the Alaskan Department of Natural Resources, the paper reviews the present status, economic advantages, and further development requirements of microhole technology for use in characterizing and producing coalbed methane resources at remote Alaskan locations. Microhole logging requirements for coalbed identification were also reviewed in the paper.

Coupled Geomechanical Deformation, Fluid Flow, and Seismic Modeling (Mobil, Schlumberger, UT-Austin, and SNL)

Highlights:

- A benchmark comparison of the results from the Sandia IPARS/ JAS3D and the ARCO ACRES shows excellent agreement for both the flow solution and the geomechanical solution
- Talk presented at the Society for Industrial and Applied Math conference.

Project efforts have focused on benchmarking the coupled IPARS/JAS3D simulator against results obtained from another coupled flow/geomechanics simulator, ACRES (Arco’s Comprehensive Reservoir Simulator), which was developed at Arco. ACRES performs compositional and black oil reservoir flow calculations that are fully coupled with poroelastic and poroplastic reservoir deformations.

Project researchers selected a problem having both an injecting well and a producing well in the simulation. With the use of no-flow and symmetry boundary conditions, this model simulates a 5-spot pattern. The problem has ten layers with uniform, elastic geomechanical properties in each layer. The orthotropic permeability varies from layer to layer and remains constant throughout the calculation. The porosity is constant in each layer initially, but varies with volume strain.

A comparison of the results from IPARS/JAS3D and ACRES shows excellent agreement for both the flow solution and the geomechanical solution. Displacement histories of the surface nodes above the injector and producer show agreement within a few percent for the entire 25-year calculation. This is very encouraging and more calculations will be performed during the next reporting period.

A talk was presented in Boulder, CO, at the Sixth Society for Industrial and Applied Math (SIAM) Conference on Mathematical and Computational Issues in the Geosciences, June 11-14, 2001. The talk, “Coupling of Fluid Flow and Geomechanical Deformation Modeling for Time-lapse Seismic” was written by Susan E. Minkoff, University of Maryland, Baltimore County; Mike Stone, Sandia National Labs; Steve Bryant, Malgo Peszynska, and Mary Wheeler, all of UT Austin.

Semiautomatic System for Waterflood Surveillance (Chevron, Case Services, and LBNL)

Highlights:

- Time-lapse satellite InSAR images added to the surveillance system.

A global analysis of the evolution of an entire giant oilfield is now feasible. The oilfield can be viewed as a single complex system consisting of reservoir rock and fluids, coupled injectors, and producers. The vertically averaged aerial signatures of primary and waterflood projects in the field can be tracked in time as the displacement of ground surface above these projects. The Synthetic Aperture Radar interferograms (InSAR) from satellites are the enabling technology.

A new element was added to the multilevel, integrated surveillance and control system: time-lapse satellite InSAR images of the oilfield surface. Ten differential InSAR images of the South/North Belridge and Lost Hills Diatomite fields, CA, between April 1995 and December 1999, were analyzed. The images were reprocessed and normalized to obtain the ground surface displacement rate. Project researchers were able to calculate section-by-section the net subsidence of ground surface over the entire field areas. The calculated subsidence volumes are thought to be close to the subsidence at the tops of the reservoirs. The images show that the rate of subsidence has decreased in some parts of Lost Hills and Belridge, while it increased in others.

Using the production and injection data from the California Conservation Commission and Chevron, project researchers were able to demonstrate the remarkable behavior of both fields:

1. There is a recirculation of injected water through the “tubes”of damaged soft rock that link injectors with producers, resulting in diminished pressure support from the waterfloods.
2. Despite more water injection, there is more subsidence in Sections 29, 34, and 33 in Belridge, and in Sections 29, 4, 5, and 32 in Lost Hills.
3. As much of the injected water is recirculated, the rate of subsidence is proportional to water production rate.
4. Compaction remains an important mechanism of hydrocarbon production.
5. In addition to accelerated compaction in the densest and most advanced waterfloods, there is a sizable oil production response to water injection.

A semi-automatic system of injection rate-pressure data acquisition and analysis is being developed. Specifications and standards for injection control system with remote control were worked out through a series of weekly teleconferences. A computer network system for transferring data directly from the field to a remote computer for processing and sending the results back to the well valve activators in the field was set up and tested. Data parsing software for processing data at an LBNL computer was also developed.

Mechanisms of Oil Recovery and Validation of Corefloods (Chevron, Phillips, and LBNL)

Highlights:

- First version of depositional model developed.
- Electron microscopic images revealing the unusual pore structure of Diatomite rock obtained.

The first version of a depositional model based on 2D PFC was developed. The depositional model mimics a North Sea chalk with a porosity of 40%. Simulations of damage propagations under increasing stress were run and strain-stress curves based on micro-mechanical modeling were obtained. The simulations show in great detail the mechanisms of development of numerous microcracks.

Electron microscopic images of Diatomite samples were obtained at resolutions of 1 micron. The images reveal the unusual pore structure of Diatomite rock. The chaotic structure of pore space may require development of qualitatively new approaches for adequate modeling of fluid flow.

Work on the Advanced Light Source (ALS) rock-imaging beam continues. This beam will make it possible to create submicron resolution in 3D images of rock.

The MatLab version of the primary drainage network simulator is being converted into ANSI C++ standard code to be used on different platforms. The code will be transferred to Phillips Petroleum as a part of participant cooperation.

Lifetime Performance Monitoring of Synthetic Fiber Mooring Ropes (Burlington Resources, GX Technology, and ORNL)

Highlights:

- FY01 funding received and work began.
- Meetings with participants planned.

The project goal is to develop and demonstrate a reliable and robust method for monitoring strain in braided and twisted-strand Synthetic Fiber Mooring Ropes (SFMR). The ultimate objective is to develop a strain monitoring system for deployment on SFMR that anchor deep-water platforms in the Gulf of Mexico.

The petroleum exploration industry is intensely interested in deploying SFMR in the near future. Hence, the Materials Management Service (MMS) of the U.S. Department of the Interior anticipates requests to use SFMR and is funding research to investigate the damage tolerance of this unique class of structure. Project work will be closely coordinated with the MMS damage tolerance program.

The project received FY01 funding in July, and immediately began the initial task of demonstrating that the technology is capable of achieving the desired strain measurements. This lab-scale demonstration will be conducted principally at ORNL. Methods for achieving project design parameters in the areas of system response time will be tested; strain resolution, precision and accuracy; measurement intervals; gauge length; system portability; and maximum and minimum strain detection capabilities. Strategy meetings with exploration industry collaborators for an accelerated development schedule will take place in the next few months.

Drilling, Completion, and Stimulation Technology

Real-Time Coiled Tubing Inspection System (Quality Tubing and INEEL)

Highlights

- Hall probe system completed and used to test samples.

The final report should be completed during August.

Perforation Dynamics in Geological Media (Columbia Gas Transmission, Halliburton, National Fuel & Gas Supply, Panenergy, and LLNL)

Report not received.

Drill Cuttings Injection Field Experiment (BP Amoco, Chevron, Exxon, Gas Research Institute (GRI), Halliburton Energy Services, Hughes Christensen, MSD, Pinnacle Technologies, Schlumberger, Shell, and SNL)

Project is in close-out phase; reporting and technology transfer are under way.

Seismic Stimulation for Enhanced Production of Oil Reservoirs

(AERA Energy, Applied Seismic Research, Chevron, Conoco, Fluidic Technologies, Halliburton, Marathon, OGCI Management, PerfClean, Phillips, Piezo Sona-Tool, Texaco, UC-Berkeley, LANL, and LBNL)

Project completed.

In-Well Imaging and Heating: Multiple-Use Well Design

(Aera Energy LLC, Chevron, SteamTech Environmental Services, and LLNL)

Report not received.

3D Analysis for Induction Logging in Horizontal Wells

(BP Amoco, Chevron, Conoco, Electromagnetic Instruments, Exxon, Halliburton, Mobil, Phillips, Schlumberger-Doll, Shell, Texaco, Unocal, Western Atlas, and SNL)

Highlights:

- Progress results to be presented at the SEG meeting.

Progress on induction log analysis for electrically anisotropic formations has focused on two areas: development of inversion algorithms and optimization of the 3D forward problem. Xinyou Lu and David Alumbaugh recently developed an approach to the inverse problem. The response of a 3-component tool dipping 45 degrees in a horizontally layered formation with horizontal anisotropy is evaluated analytically using a previously developed 1D solution. After adding Gaussian noise to these synthetic data, they are then inverted for the four-anisotropy parameters. For the models tested, the inversion results compare favorably with the known model, thus demonstrating the utility of 3-component tool data for accurate assessment of formation conductivity.

In the area of improving the speed of 3D forward computations to evaluate more complicated geologic structures, Chester Weiss and Gregory Newman have been working on a matrix-free formulation of the finite difference staggered grid solution to the Maxwell equations. The matrix-free formulation reduces the computational burden of the forward problem by eliminating direct storage of the finite difference coefficient matrix. Benchmark tests indicate this new formulation can also improve the speed of algorithm, resulting in a decrease of CPU time of approximately 20%, depending on the size of the problem and hardware used.

Results of progress in each of these research areas have been selected for presentation at the upcoming Society of Exploration Geophysicists (SEG) meeting in San Antonio, TX.

Downhole Seismic Source for Look-Ahead Pore Pressure Prediction While Drilling

(Chevron, INEEL, and LBNL)

Highlights

- Feasibility report completed.

The INEEL design team continues the design and construction of two seismic sources for Pore Pressure Prediction (a.k.a. Ahead of Drill String Seismic Source). The two sources are the Plasma Spark (now known as capacitor discharge seismic source) and the regenerative combustion seismic source.

The design of a prototype capacitor discharge seismic source device is nearing completion. Parts and material were ordered, and fabrication has started. The regenerative combustion seismic source is comprised of components previously tested in the Arkansas experiments, and is therefore more complete. This early prototype is less like a drill string deployable tool than the current capacitor discharge seismic source design. Nevertheless, performance improvements were performed on the regenerative combustion seismic source, and both will be tested later this fall.

A bench-scale test apparatus for ascertaining the effects of pressure on the capacitor discharge seismic source is planned, and components were ordered.

Acoustic Telemetry (MWD)

(ABB, Passband Downhole Communications, Electroacoustics Research Laboratory, and SNL)

Highlights:

- Field test rescheduled for September.
- System tests achieve 33 baud.

Hardening of the two prototype tools continues at Extreme Engineering. Hard mounting of all circuit boards and power supply components on the first tool were completed. That tool operates at full voltage and efficiency.

Slight delays have occurred in delivery of some of the hardening components. This affects the test date, which has slipped to September. Project researchers used a second tool, Orpheus, to run integration tests at Sandia's surface facility. The demodulation code, Babel, was tested at a variety of communication rates. It operated reliably at all uncompressed data rates up to 33 baud, which is a factor of 10 above mud pulse telemetry rates. These rates are expected to double or triple in the future. The second tool is in transit to Extreme Engineering for hardening modifications in preparation for the September field test.

Development of Chemically Bonded Ceramic Borehole Sealants

(GPRI, ANL, and LANL)

Highlights:

- Researchers developed a novel method to process MgO to form borehole sealants at higher downhole temperatures and pressures.

Previous testing at Chevron established that the Ceramicrete formulation is valid for applications in wells with varying depths, but considerable uncertainty in data exists. It appears that this uncertainty arose because the thickening time was close to 3 hours, a minimum time needed, and therefore barely passed the criterion. To make the borehole sealant a very rugged material that will forgive minor variations in the composition and powder processing variables, it is necessary to slow down the setting reaction further. This implies that reactivity of magnesium oxide (MgO) used in the process should be reduced further.

During the last two months, two different formulations were developed by reducing the solubility of MgO. In the first case, a setting time of 100 to 120 minutes was obtained, and in the second case at least 3 hours at ambient temperature and pressure. This is without adding any retardant. These setting times are two to three times that of the normal setting time of powders used in the previous studies. Using boric acid, ANL was able to extend the time to over six hours. These powders will be tested in the automated consistometer to be received from the manufacturers this month.

LANL conducted a demonstration to show that the ceramic borehole sealant can be pumped through the casing and back to the surface up through the annulus, thus stabilizing the entire system. The site had a moist sandy red impermeable clay.

Two tests were conducted, one with a mild steel pipe and the other with a PVC pipe. In each case, the depth was a modest 6.5 ft. The diameter of the borehole was 6 in. The steel pipe had an inner diameter of 2.5 in. and the PVC pipe had an inner diameter of 3 in. In each case a total of 128 pounds of slurry was mixed in a concrete mixer and poured through the pipes. It was then pushed with a plug to the bottom and the plug was left at the bottom to seal the pipe. The slurry moved up smoothly from the annular space and stabilized the pipes. After ten days, the steel pipe was excavated along with the set ceramic, but the PVC pipe could be retrieved with a formation of ceramic borehole sealant forming its own pipe of the size of outer diameter of the PVC pipe.

This demonstration shows that Ceramic borehole sealant is a practical material that behaves as a pumpable borehole sealant. Based on this experience, a larger demonstration is being planned.

Coiled-Tubing Deployed Microdrilling with Real-Time, Downhole Monitoring (DeepLook, Phillips, Texaco, and LANL)

Highlights:

- Second San Ysidro well suspended at 360 ft.
- Surface casing for a third well set.

Regulatory approvals to drill on the second site were obtained. The new drilling site is located on a hill 130-ft higher than the first well to avoid artesian flow if the aquifers that flowed on the first hole are penetrated. 100 ft of 2-7/8-in. line pipe was cemented into a 4-in. auger-drilled hole to serve as surface casing for San Ysidro Well No. 2a. The coiled tubing was rigged up and a 2-3/8-in. hole was drilled to 135 ft. The drilling assembly was changed out and a 1-3/4-in. hole was advanced at 200 to 300 ft/hour through poorly consolidated sand. At 360-ft depth the penetration stopped and the drilling assembly was to be pulled for inspection. The drilling assembly was not recovered and the shear pins in the safety joint had sheared. Once a fishing assembly was mobilized and run, there was 7 ft of fill over the fish. Attempts to wash down to the fishing neck on the drilling assembly were unsuccessful. A 2-3/8-in. drilling assembly was run and the hole was reamed out from 135 ft to the top of the fish. The drilling assembly was removed and the fishing assembly was run to the top of the fish, but repeated attempts to wash the overshot onto the fishing neck were unsuccessful. A larger grapple was run with the same results. The coiled-tubing deployed fishing was suspended.

A washout in the head and discharge valve seat on the mud pump caused operations to be suspended during the fishing on Well No. 2a. Replacement parts were shipped and the pump was repaired. The cause of the pump failure has not been determined.

A third well was spudded and 100 ft of 2-7/8-in. line pipe was cemented into a 4-in. auger-drilled hole to serve as surface casing for San Ysidro Well No. 2b.

Effects of Well Conditions on Post-Perforation Permeability (Halliburton, Penn State, and LLNL)

Funding was not received until this month. As a consequence, personnel were reprogrammed and all project milestones were delayed a minimum of four months from the original schedule.

Previous tests on Berea sandstone mapped the magnitude and spatial extent of the reduced permeability zone around the perforations for two levels of underbalance. A fines migration model, linked to hydrocode simulation of the perforation process, produced reasonable agreement with experimental permeability maps. However, particle size distribution and initial fines concentration were not measured. To better constrain the modeling process, project researchers are recovering material from around the perforations of previous tests to map the particle size.

Diagnostic and Imaging Technology

Advanced Sensor Technology for Microborehole and Other Seismic Instrumentation (Input/Output, Texaco, and LANL)

Highlights:

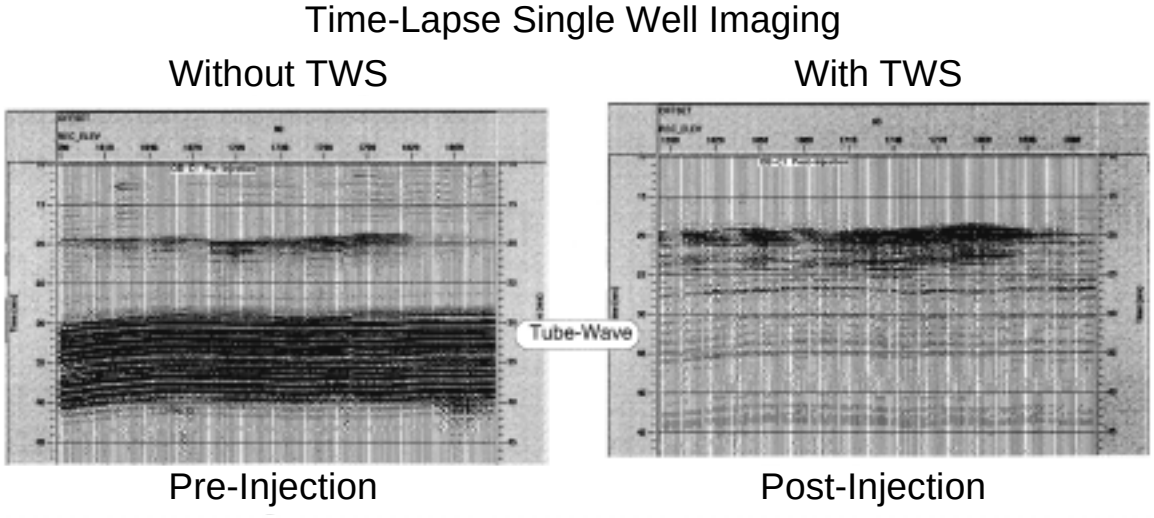
- Preparations completed for testing of the microhole array in the San Ysidro microhole.

Two, four-level MEMS arrays were completed and fully bench tested. Field testing and evaluation of the array will begin on completion of the San Ysidro microhole.

Development of Single-Well Seismic Imaging Technology

(BP Amoco, Chevron, Conoco, Exxon, OYO Geospace, P/GSI, Phillips, Schlumberger, Shell, Texaco, TomoSeis, Unocal, Western Atlas, Stanford, LBNL, SNL, and INEEL)

LBNL continues to perform tests on the INEEL tube wave attenuator under field conditions at Chevron's Lost Hills site. The tests were run at 2000-ft depths with the attenuator between the LBNL/Conoco piezoelectric source and a 24-level hydrophone string. The figure below shows the attenuation of the tube wave, approximately 60 db. The difference in the first arrival is due to an injection (this was a time lapse experiment).



Large Downhole Seismic Sensor Array

(Chevron, Conoco, Exxon, OYO Geospace, Shell, Texaco, U of Arkansas, and INEEL)

Highlights:

- Construction of demonstration prototype begun.

The final report draft is back from editing. Comments and corrections have been incorporated. The draft was modified with the addition of design photographs. Printing was completed in June.

Improved Prestack Kirchhoff Migration for Complex Structures

(Conoco, Cray/SGI, Golden Geophysical, Kerr-McGee, Mobil, Shell, and LANL)

Highlights:

- 3D Wavefront construction code implemented; testing initiated.

Project researchers have implemented a simplified approach for doing wavefront construction in 3D. The simplified approach is aimed at keeping bookkeeping manageable for the 3D problem by making certain assumptions about where to add rays during the construction scheme. While this code will not be used in migration, the approach offers a way to easily accomplish wavefront construction ray tracing in 3D. This code is currently being validated against other methods for doing 3D traveltime calculations.

Testing Advanced Computational Tools for 3D Seismic Analysis Using the SEG/EAGE Model Dataset

(Advanced Data Solutions, Anadarko, BHP Petroleum, BP Amoco, Burlington Resources, Chevron, Conoco, Edison Chouest Offshore, Exxon, GECO-Prakla, Golden Geophysical, Kerr-McGee, Marathon, Mitchell Energy, Mobil, Paradigm Geophysical, PGS-Tensor, Phillips, Shell, Society of Exploration Geophysicists [SEG], Texaco, Union Pacific Resources, Unocal, Western Geophysical, Houston Advanced Research Center/Rice, Stanford, UC-Davis, U of Houston, LANL, LLNL, and ORNL)

Highlights:

- Processing of physical model vertical cable data begun.

The Texaco software package, "Seispak", will be used for preprocessing and imaging vertical cable data for the physical salt model. It was reinstalled on the AGL workstation to fix previous problems. The processing flow for the vertical cable data was planned as follows:

1. trace interpolation to make 25 × 25 -m grid spacing
2. deconvolution
3. amplitude equalization (if necessary)
4. PSPI (Phase Shift Plus Interpolation) migration
5. Kirchhoff prestack depth migration
6. comparison of PSPI and Kirchhoff prestack depth migration.

The next step is to build the 3D velocity model for imaging.

Integrated Reservoir Monitoring Using Seismic and Crosswell Electromagnetics

(Chevron, Electromagnetic Instruments, TomoSeis, LBNL, and SNL)

The third and final crosswell EM survey at the Lost Hills carbon dioxide (CO_2) pilot was completed at the beginning of July. The data was processed and inversion to produce conductivity sections has begun. Additional work was completed on the rock properties model that relates velocity and density to reservoir parameters (saturations and pressure). New lab data from Chevron was received. It further confirms the accuracy of the model for linking velocity changes in the reservoir to changes in pressure and fluid saturations.

Project researchers are now attempting to pick shear wave arrivals from crosswell seismic data to produce shear wave velocity sections. If changes in shear wave velocity can be successfully estimated in addition to previously estimated changes in p-wave velocity and electrical conductivity, researchers should be able to estimate water saturation, gas saturation and pressure changes independently from the flow simulation predictions.

Frequency-Dependent Seismic Attributes of Fluids in Poorly Consolidated Sands

(Baker-Atlas, Chevron, TomoSeis, Vastar, and LBNL)

Work during focused primarily on two efforts: (1) redesign and testing of a combined torsional-extensional wave sonic frequency apparatus for sands, and (2) development of 2D and 3D finite difference simulators for wave propagation in a poroelastic with patchy saturation.

Extensive testing on the torsional-extensional wave sonic frequency transducers for poorly consolidated sands demonstrated that the effects of the large mass of the steel transducer housings resulted in spurious torsional wave resonances and amplitude reduction. To correct this problem, both the source and receiver transducer housings were completely redesigned. The new design incorporates a lightweight aluminum housing and an epoxy potting material to shield the sensors from the confining pressure. Project researchers are in the process of assembling and testing these transducers. When these tests are complete, the testing program on sands will be resumed. The attenuation and veloc-

ities of limestone obtained through collaborative work with Jorge Parra (Southwest Research Institute), and cores from an Absheron well provided by Chevron will also be measured.

The second effort has focused on the development of 2D and 3D finite difference codes for the numerical simulation of wave propagation in poroelastic rock with multiple fluid and gas phases. These codes incorporate basic Biot poroelasticity using an explicit, velocity-stress finite difference formulation. Memory variables are used to describe the frequency-dependent viscosity factor, extending the computational capabilities over the full frequency range. The first 2D code has been written and is being debugged. We plan on using these codes to examine the role of gas saturation heterogeneity on the velocities and attenuation of P- and S-waves, and to determine if our measurements on sands are consistent with the model predictions when the gas-water distributions obtained from our X-ray computer tomography (CT) images are used in the numerical modeling.

Inversion of Full Waveform Seismic Data for 3D Elastic Parameters

(Amerada Hess, Conoco Fairfield Industries, GX Technology, Marathon, Texaco, Unocal, and SNL)

Highlights:

- Testing of the parallel version of the full waveform inversion algorithm using simple elastic earth models and synthetic seismic datasets continues.

Testing of the parallel version of the full waveform inversion algorithm using simple elastic earth models and synthetic seismic datasets continues. Two models of high interest are (1) isolated point diffractors and (2) 1D layered structures. The point diffractor model enables us to investigate the ability of the algorithm to identify and distinguish different material properties (compressional or shear wavespeeds, elastic moduli, P- or S- impedance, mass density) that are associated with the diffracting locus.

Feedback from industry participants indicates that the 1D layered earth model is a realistic yet simple model of practical utility importance for petroleum exploration purposes. Various recording geometries are also being studied with each of these earth models.

Finally, work continues on a SAND report documenting the basic theoretical framework of full waveform elastic inversion, as developed from the reciprocity principle.

High-Speed 3D Hybrid Elastic Seismic Modeling

(Burlington Resources, GX Technology, and LBNL)

Report not received.

Next-Generation Seismic Modeling and Imaging

(Advanced Data Solutions, Anadarko, BHP Petroleum, BP Amoco, Burlington Resources, Chevron, Conoco, Exxon, GECO-Prakla, Marathon, Mobil, Paradigm Geophysical, PGS-Tensor, Phillips, Shell, Society of Exploration Geophysicists [SEG], Texaco, Union Pacific Resources, Unocal, Western Geophysical, Stanford, U of Houston, LANL, and LLNL)

Highlights:

- Elastic modeling code being modified to include anisotropy.
- Candidate 2D and 3D elastic models identified.

As part of the effort to investigate the diverse geologic and geophysical parameters being considered for the next generation of Society of Exploration Geophysicists (SEG) models, general and case-specific anisotropic mechanisms are being incorporated into the project's seismic modeling software. In addition, an efficient acoustic-only modeling capability is being implemented, as requested by an industry participant.

Industry participants have provided numerous suggestions have been received from industrial collaborators for the next set of 2D and 3D seismic models, which should be tested with the E3D elastic modeling code. The

project will demonstrate, through this effort, the importance of understanding complex wave phenomena for obtaining better images of subsurface exploration targets. New models to be investigated include structures based on existing land and marine surveys conducted in regions such as the Gulf of Mexico, the New Mexico Rift, the Canadian Rocky Mountain overthrust, and strike/slip structures in ocean/continent boundaries. Of particular interest are long-offset surveys over complex structures that produce strong converted phases, anisotropic effects and mode conversions. Plans to use E3D for generating synthetic seismic surveys over the 3D SMAARTJV salt model are also being discussed.

Rapid Imaging of Interwell Fluid Saturations using Seismic and Multiphase Production Data

(BPAmoco, Chevron, JNOC, Landmark, Phillips, RC2, Statoil, Tomoseis, Total-Fina-Elf, Texas A&M, and LBNL)

Highlights:

- Funding received.

Funding for this project was received in June. Work has started, based upon industry funding through Texas A & M.

In particular, the streamline-based inversion method has been applied to partitioning interwell tracer data from the Ranger Field in Texas.This method involves conducting two tracer tests. The first uses a conservative tracer that does not react with subsurface fluids. The second test uses a partitioning tracer that reacts with the oil in the reservoir. The chromatographic time separation between these tracers measures the oil saturation between the various wells.

Project researchers developed a very fast streamline-based inversion scheme in which the results of such tests can be analyzed in a matter of minutes or hours. Using this technique, the swept volume in a 320-acre area of the Ranger Field (which included 13 production and 4 injection wells) was analyzed.

The water-cut inversion code was generalized in several respects. Using dynamically allocable arrays allows researchers to solve large simulation problems, approaching 1 million cells. Also, gravitational effects and rate schedule changes were included in the inversion code. Combinations of production data such as water-cut, tracer, and transient pressure observations can now be utilized.

LBNL and Texas A&M have signed an agreement with an industry participant to obtain 3D time lapse and production data from a producing Gulf of Mexico field. The project is setting up a reservoir simulation and preparing to begin an inversion of the water-cut data from the field. Project researchers are also examining the time-lapse seismic data for attributes related to saturation changes within the producing horizon.

Innovative Wave-Equation Migration

(Advanced Data Solutions, Amerada-Hess, Applied Geophysics Services, Baker Atlas, BHP, Conoco, Exxon-Mobil, Fairfield Industries, GX Technology, Petroleum GeoServices, Phillips, Screen Imaging, Shell, Texaco, TomoSeis, Unocal, Veritas DGC, and LANL)

A project organizational meeting was held at Conoco Center in Houston on June 27. Thirty participants from 15 companies attended the meeting. Project researchers provided a general review of research on wave-equation migration that has been conducted, then solicited comments and suggestions from industry participants. They expressed their great interest in wave-equation migration and provided valuable suggestions.

A theory of a new migration algorithm termed the split-step Pade method was developed. 2D synthetic data will be used to verify the method. Investigations have commenced on the amplitude reliability of the Born-based migration method that the project has developed. Theoretical studies of a higher-order quasi-Born Fourier migration method that might have potential for amplitude-preserving migration are also being conducted.

Testing and Validation of High-Resolution Fluid Imaging in Real Time

(Deeplook, KMS Technologies, KJT Enterprises, LBNL, and SNL)

Highlights:

- Project begins.

LBNL and SNL met with Deeplook and KMS to kick off the project. LBNL and SNL will perform sensitivity analysis of seismic and electromagnetic (EM) response of several models, provided by Shell. LBNL also met with KMS to commence design and specifications of the LBNL single well seismic system for integrating the EM system.

Partnership Office

Following the guidance from DOE, the Partnership is proceeding with the upstream technology area's FY02 call and schedule for new proposals and continuing projects. The call and schedule for environmental technology areas, both Upstream and Downstream, will be announced shortly.

Schedule for Upstream Technology Areas:

Sept. 10 (Monday):

- OGRT pre-proposals and cards sent to Mike Hoversten.
- DIT pre-proposals and cards sent to Jim Albright.
- DCST pre-proposals and cards sent to Charles Thomas.

Sept. 14 (Friday):

- Forum Leads send out packages of the one-page pre-proposals and cards-on-the-table to the respective industry panelists, to the Partnership representatives, and DOE project managers.

Sept. 28 (Friday):

- Industry panelists return pre-proposal review forms with their ranking to the Forum Lead. DOE program managers invited to submit their comments.

Oct 10 (Wednesday):

- Via a conference call, Partnership Office agrees on selection of new proposals to be presented. Each Forum Lead will present his recommended slate of new projects to be presented to the Industry Panel.

Oct 11 (Thursday):

- Partnership Office requests full proposals from the principal investigators.

Oct 29 (Monday):

- Final OGRT proposals received at Berkeley.
- Final DIT proposals received at LANL.
- Final DCST proposals received at INEEL.

Nov. 1 (Thursday):

- Forum Leads mail (or email) proposal packages to Industry panelists, to all lab representatives, and to DOE program managers.

Nov 13, 14, 15 (Tuesday-Thursday):

- OGRT, DCST, and DIT Review Meetings, (Sheraton North Houston). Meetings are held on consecutive days in Houston, near the Bush Intercontinental Airport.

Tentative Schedule for Environmental Technology Areas:

August 6 (Monday):

- Upstream Environmental Technology call issued.

August 8 (Wednesday):

- Downstream Environmental Technology call issued.

Sept. 4 (Tuesday):

- Pre-proposals and cards-on-the-table due to forum chairs.

Sept. 6 (Thursday):

- Pre-proposals and cards-on-the-table due to industry panelists, partnership representatives, and DOE.

Sept. 20 (Thursday):

- Pre-proposal reviews and ratings due from industry panelists.

Sept. 21 (Friday):

- Ratings and comments sent to partnership representatives and DOE.

Sept. 26 (Wednesday):

- Partnership conference call; select new-start proposals.

Continued on Page 14

Partnership Office Continued

Continued from Page 13

Sept. 27 (Thursday):

- Lab reps notify principal investigators of selection/ non-selection for full proposals.

Oct. 12 (Friday):

- Full new-start and continuation proposals to chairs.

Oct. 16 (Tuesday):

Proposal packages to industry panelists by email/overnight delivery.

Oct. 24 (Wednesday):

- Upstream environmental review in Houston.

Oct. 25 (Thursday):

- Downstream environmental review in Houston.